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ABSTRACT

This study compared the conceptual rule learning performance of normal and learning disabled children. Subjects for the study were 18 normal and 18 learning disabled children with mean ages of 9.4 and 9.3 years and mean IQ scores of 103.1 and 101.6 respectively. The children were matched for age, IQ, sex and race. Four types of rules (affirmation, conjunction, disjunction, conditional) and the use of familiar and nonfamiliar shapes were used to test the children's ability to identify relevant attributes and to apply the necessary concept formation rule. The effect of changes in rule complexity was also analyzed. The task for the study involved the identification of positive and negative instances of a concept involving a pair of relevant attributes, one of which was always shape. Results from the study indicated that rule learning was retarded by increasing rule complexity for all children. Learning disabled children, however, demonstrated significantly poorer performance than normal children on all tasks. Shape familiarity increased the success of normal children on the most difficult problems but had no corresponding effect on learning disabled children. The results are discussed in terms of possible processing deficiencies and the difficulty inherent in the comprehension of negative instances in concept formation tasks. (BD)

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CONCEPTUAL RULE LEARNING IN NORMAL AND LEARNING DISABLED CHILDREN

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ABSTRACT

Conceptual rule learning performance of normal and learning disabled children, matched on CA, MA, and sex was compared using a modified reception paradigm. Four types of rules (affirmation, conjunction, disjunction, conditional) and familiar and nonfamiliar shape attributes were used to test Bournes (1974) stimulus-encoding hypothesis. Main findings indicated learning disabled children were deficient on all conceptual rule tasks compared to normal children on an experimental paced continuous reinforcement schedule. Expected differences in rule complexity were found; however, disabled children's conceptual rule response difficulties did not compare with normals. Manipulation of the attribute of shape familiarity produced only discernible saliency advantages in normal children. It was hypothesized that learning disabled children were poor in problem solving due to deficit in the comprehension of negative instances.

Conceptual Rule Learning in Normal and Learning Disabled Children

Two frequently mentioned characteristics associated with learning disabled children of normal intelligence is their rigidity in thinking and difficulty learning new concepts. While the paradox of children with normal intelligence having cognitive deficits has been widely accepted, little research can be found on the conceptual functioning of learning disabled children, apart from frequent observations of poor school performance (e.g., Bryon & Bryon, 1975; Hallahan, 1975) or a typical subtest scatterings (e.g., Vance & Gaynor, 1976). Learning disabled children's poor cognitive performance is usually interpreted from standardized tests and clinical evidence as resulting from a number of specific learning deficits (e.g., reading, spelling, and/or number concepts). Several authors (e.g., Kleuver, 1971; Kinsbourne, 1975) have suggested that conceptual difficulties of learning disabled children reflect reasoning or concept formation disorders related to their inability to identify critical features or characteristics of objects or events and then specify the appropriate relationship between those features. However, the sparse experimental studies available have not found support for these assumptions (e.g., Firestone, 1974; Freiberg & Douglas, 1969).

Specifically, Freiberg's and Douglas' (1969) earlier study did not find the presence of a cognitive deficit in learning disabled (e.g., hyperactive)

children. Their findings argued quite strongly against the currently held opinion that learning disabled children suffer from basic deficits in the fundamental stimulus-encoding operations involved in the concept formation process; namely, abstraction of stimulus dimensions, production of symbolic categorization responses, and modification of response strategies on the basis of informative feedback. Comparison of the learning disabled and normal children indicated no significant difference in concept learning under a self-paced continuous reinforcement schedule. A hypothesis offered by the authors was that learning disabled children's difficulty in problem solving was motivational rather than conceptual since learning differences occurred only under conditions where correct responses were occasionally reinforced. This study, taken together with others (e.g., Firestone, 1974; Juliano, 1974) suggests learning disabled children may be overdependent on continuous reinforcement. Perhaps a failure to find conceptual learning differences between normal and learning disabled children reflected sample definitions, lack of variation in conceptual rule difficulty, and subject pacing procedures. Nonetheless, their findings seriously question the adequacy of a conceptual deficit assumption applied to learning disabled children.

The purpose of the present study was to provide some experimental evidence on the question of cognitive impairments by systematically comparing performance of normal and learning disabled children on a conceptual rule task. In contrast to previous studies, rule complexity differences were investigated on a fixed pace continuous reinforcement schedule. In order to account for data in present study, the stimulus-encoding hypothesis proffered by Bourne (1970) will be used to interpret normal and learning disabled children's performance. According to

Bourne (1970), a concept is defined in terms of relevant attributes and the rule specifying the manner in which these attributes are used to determine category membership of various stimuli. A reliable finding within conceptual learning involves an ordered difficulty in rule application (Bourne, 1970). Initially, if Y and S stand for yellow and star (relevant attributes of the rule), there are clear differences in rule difficulty; conjunctive $(Y \cap S) <$ disjunctive $(Y \cup S) <$ conditional $(Y \rightarrow S)$[1]. According to the aforementioned stimulus-encoding hypothesis in the case of conjunctive rules, the child maps the entire stimulus population into stimulus subclasses (e.g., color - red, yellow, green; shape - circle, triangle, star; number - one, two, three - of figures) based on the presence or absence of two relevant attributes (e.g., yellow and star). The child then prescribes the assignment of each subclass to example (positive instance) and nonexample (negative instance) categories. For instance, the child on the conjunctive rule task assigns members of the sub-class containing both relevant attributes as examples and all others as nonexamples of the concept. To understand, recognize, and employ the concept, a child must know a particular relationship among a particular set of stimulus characteristics.

The design of present study compared learning disabled and normal children's problem solving behavior of class concepts in which four types of rules (affirmative, conjunction, disjunction, conditional) were used.

The present study also involved the application of two verbal learning variables on one attribute - shape familiarity and nonfamiliarity. Color and number have been found to have saliency on various familiar and nonfamiliar tasks (e.g., Ellis, 1970), while saliency of shape is in question. Further, a priori comparisons were made within groups to compared rule difficulty levels.

Method

Subject and Design

Thirty-six children, half normal and half learning disabled, matched on CA, IQ, sex, and race from Richland County Public School District, Columbia, South Carolina, served as subjects. Computed mean IQ scores from the Otis-Lennon Test and mean CA's were 101.6, SD = 7.85; 9.4, SD = .30 for learning disabled and 103.1, SD = 6.13; 9.3, SD = .43 normal children respectively. The two groups did not differ significantly on IQ or CA ($t<1$). Further learning disability selection included below the 40th percentile on a standardized reading test. Reading achievement of the learning disabled group ranged from 40 to 25 percent below expected reading grade level (a minimum of 2.0 years discrepancy). Classification of learning disabled children was based upon the South Carolina State Standards (National Advisory Definition) and the Review and Appraisal Committees in the respective school districts. None of the children were on medication. An equal number of male and female (normal and disabled) children were randomly assigned to either the familiar or nonfamiliar conceptual rule task. Conceptual rule (affirmative, conjunction, disjunction, conditional) task presentations were randominized for each child with order

of presentations counter-balanced. A 5-minute rest period was provided between each rule learning task. Approximate time of each individual session was 50 minutes. All children participated in both familiar and nonfamiliar conceptual rule tasks, with a two-week interval between tasks.

Procedures and Material

The procedure used in this study was similar to Cohill and Hovland (1960) simultaneous presentation technique. This procedure was a simplified variation of the reception paradigm used in adult conceptual studies (see Bourne, Ekstrand & Dominowsky, 1971, for review). The entire stimulus population was laid out before the child, permitting access to all previously identified and yet to be identified stimuli. Three dimensions with three attributes or values per dimension were employed in all rule-learning problems with number (1, 2, 3) and color (red, yellow, green) common to all problems. In addition, shapes for the familiar condition was circle, triangle, and star while nonfamiliar shapes included numbers 19, 22, and 25 from Vanderplas and Garvin's (1959) eight-point random shape assortment. Stimuli were drawn on 10 X 10 cm white index cards. Pretesting indicated all children could label color, familiar shapes, and numbers. Pretesting indicated that children did not have a label for the eight-point random shapes. Directions included the experimenter saying, "We are going to play a game. I have some cards--some are worth chips, some are not. For each card you choose correctly, you get a chip. After we are through today, you may turn your chips in for a prize." Prizes were specified and given certain token values. All stimulus cards (27 for each rule) were then laid out before the child. In all rule learning problems, a pair of relevant attributes were shown to the child at the onset of the task (one attribute of the shape dimension was always relevant). The experimenter then chose a

single predetermined stimulus card from the array. The child responded by classifying that stimulus card as an example or non-example of the concept within ten seconds after stimulus selection. Children's response was followed by informative feedback--a "yes" or "no" indicating whether or not the response was an example or nonexample of the concept. Then, another predetermined stimulus was shown, followed by a response and feedback. Stimulus presentation, child response and experimenter feedback constituted one trial. All children who did not reach criterion had been exposed to each card twice in the predetermined series. Criterion for problem solution on the conceptual rule was ten consecutively correct responses in 54 trials.

Results

Of the 36 children, 9 children were unable to meet criterion of problem solution for 8 (4 each for familiar and nonfamiliar shape group) conceptual rules within 54 trials. All nonsolving subjects were, therefore, arbitrarily assigned a score of 60 trials, a value which reflected differences between the child who required over 44 trials to solve and those who did not solve the problem. While the inclusion of data from the nonsolving children was not entirely desirable, a procedure involving their replacement would have artificially deflated means and variances. Errors through criterion were collected and analyzed. The distribution of solvers (s's reaching criterion) and of nonsolvers for each subgroup is given in Table 1. Differences between the two groups (normal vs. disabled) for nonsolvers in all experimental conditions did reach significance $\underline{X}^2$ (1) = 7.29, $p < .01$). Significantly more nonsolvers were found in the learning disabled group. Analysis of rules indicated a decreasing number of solvers for both groups on the conditional rule task. The two verbal

conditions (familiar vs. nonfamiliar) did not yield significant differences in

Insert Table 1 about here

the distribution of normal and disabled solvers and nonsolvers; $X^2 < 1$.

In Figure 1 are displayed the mean number of errors to criterion (trial of last error) on the rule learning tasks for normal and disabled children and shape

Insert Figure 1 about here

familiarity and nonfamiliarity. A 2 X (normal vs. disabled) X 2 (shape familiarity vs. nonfamiliarity) X 4 (conceptual rules) analysis of variance with repeated measures was applied to these data, the results of which showed significant sources of variation due to group, F (1, 34) = 13.76, $p < .001$; and rule difficulty F (3, 102) = 5.344, $p < .001$; but not for shape familiarity vs. nonfamiliarity, $F < 1$. As expected, rule difficulty was one source of variation.

Significant two way interactions were found for group X shape familiarity/nonfamiliarity, F (1, 34) = 40.85, $p < .001$; familiar/nonfamiliarity X conceptual rules, F (3, 102) = 16.16, $p < .01$; but not for group X conceptual rules, $F < 1$. Tests of simple-main effects indicated that the familiarity vs. nonfamiliarity shape attribute was obscured by these interaction effects. Simple-main effects for normal children indicated significantly better performance on familiar compared to nonfamiliar shape attribute F (1, 34) = 18.69, $p < .01$; but not for disabled children, F (1, 34) = 1.38, $p < .25$. A significant three-way interaction was also found, F (3, 102) = 68.007, $p < .001$.

A t-test (df) for within group conceptual rule learning was used to analyze experimental a priori concern and interaction effects for rule difficulty and

and shape familiarity. As shown in Figure 1, actual ordering for normals on

Insert Figure 1 about here

familiar shape attribute was significant ($p < .05$); CJ < DJ ($t = 19.37$) < CD ($t = 16.27$), a finding consistent with Bourne (1974). No significant difference was found between affirmation and conjunctive rules. A subsequent analysis of learning disabled children's familiar shape attribute rule order yielded AF < CJ ($t = 4.26$) < CD ($t = 31.67$), while disjunctive conceptual rule performance was significantly better than the conjunctive ($t = 34.49$). On the nonfamiliar shape attribute, normals ordering was CJ < DJ ($t = 10.85$) < CD ($t = 37.20$), with significantly better performance on affirmative compared to conjunctive rule learning ($t = 10.07$). Rule difficulty for disabled was DJ < CD ($t = 9.65$), with better performance on affirmative compared to conjunctive rules ($t = 8.13$), and no significant differences again between conjunctive and disjunctive rules ($t = 1.78$).

Discussion

Main findings indicated learning disabled were deficient on all conceptual rule tasks compared to normal children. In order for the learning disabled children to successfully solve the conceptual rule problems, they need to (a) pay attention to relevant attributes while ignoring irrelevant ones; and (b) associate each attribute with response categories defining the problem solution. Reinforcement studies (e.g., Firestone, 1974; Freiberg & Douglas, 1969; Juliano, 1974) have found when rewards are given after every trial, even after a delay of time, both learning disabled and normal children learn at the same rate, therefore, mitigating the confounding effects of attention. Based on these earlier findings, data in the present study was interpreted as reflecting cognitive deficits in learning disabled children for rule categorization responses.

Differences in conceptual rule learning was found when the learning response was fixed and rule difficulty varied.

The present results seem to argue strongly against Freiberg's and Douglas' (1969) earlier findings in which no basic deficits were found between learning disabled and normal children. Although conflicting results could be attributed to intertask differences, several other factors could account for the conflicting findings. In Frieberg's & Douglas' study, hyperactivity was the major symptom while in the present study specific reading problems were a differentiating factor. Differences were also noted in IQ scores being lower in Freiberg's and Douglas' study (M98.9 vs. M101.6), while control groups were matched only on WISC vocabulary subtest scores. One further differentiating feature compared to Freiberg's and Douglas' (1969) procedures, was that the task in the present study was paced for a fixed period of time (ten seconds); there is a possibility that learning disabled children might do better in a situation where subject assessment of stimulus "examples" or "nonexamples" are self-paced. It could be argued as suggested by other studies (Firestone, 1974; Juliano, 1974) with the subject pacing the stimulus presentation; the child may be more task oriented and less distractible. A lingering question, however, concerns whether this would have helped learning disabled children if they were truly able to function at the rule difficulty level.

The overall results of rule difficulty in the present study, although within a modified reception paradigm, replicates earlier findings with adults (Bourne, 1974) in that rule learning is retarded by increasing rule complexity. Analysis of simple-main effects in error difficulty indicated that only normals in the most difficult conceptual rules profited from shape familiarity in problem solving, while familiarity did not enhance conceptual learning for disabled children.

The specific lack of CJ < DJ rule difficulty in learning disabled children for both shape attribute conditions is interesting finding in itself and deserve further note. Unfortunately, what is not clear from the results for both groups of children is whether the difficulty of not finding rule differences was associated with failure to develop an appropriate conceptual strategy or difficulty in comprehension of negative instances (non-example). The very fact that most children ultimately solved even the most difficult problem (CD) testifies to the ability of even learning disabled children to master, implicitly, the attribute combinations. Post-hoc analysis of errors from familiar attribute rule-condition to nonfamiliar rule condition indicated that learning disabled children were not resistant to modification of response strategies on the basis of information feedback. Further, since a successive presentation was used, explanations of differences in memory failed to explain disabled children's group performance.

A possible explanation for group differences as suggested from similar developmental studies (e.g., King & Holt, 1970) is that stimulus encoding of the absence of relevant attributes is more difficult than two relevant dimensions of a rule. Learning disabled children might attend to but derive less information from negative (non-examples) than from positive (examples) instances when rules become more difficult. The proportion of negative rule instances were: affirmative (18/27), conjunction (24/27), disjunction (18/27), and conditional (6/27). This interpretation is similar to Wiig and Semel (1976) observations that comprehension of negatives frequently poses problems for learning disabled children since the structure of negatives take longer processing time. For example, in the present study, the child might verbally mediate to himself on the negative instance of the affirmative rule, "this

shape is not yellow, it is red." The child must subtract the quality of color from the attribute of shape. However, the positive instance (e.g., the shape is yellow) establishes the quality of shape.

A learning disability assumes a discrepancy between potential and achievement. But in and of itself this discrepancy between IQ and conceptual rule learning does not delineate the manner in which learning processes have been disrupted. The intricate comparison of normal and learning disabled children has scarcely been touched. Several rule processing variables are left unanswered. Why were no differences found between CJ and DJ rule learning--is the learning disabled child's problem solving behavior due to a conceptual deficit or lag? (2) What sort of pre-experimental hypotheses testing strategy was used by LD children, and (3) Why were differences found between learning disabled and normal children on even the most primative rule (affirmation). Obviously, many experiments comparing normals and learning disabled children need to be conducted to specify rule learning "breakdown," and the transfer value of a rule learned.

Footnotes

[1] Read "<" as easier. Verbal descriptions of rule examples include: conjunction - every pattern yellow and a star; disjunction - yellow or a star or both; conditional - yellow star or any shape not yellow. Also included in the present study was the simplest rule: affirmation - every yellow pattern.

TABLE I

Number of children per rule who reached criterion performance on familiar or nonfamiliar shape attributes

Rule	Normals				Disabled			
	AF	CJ	DJ	CD	AF	CJ	DJ	CD
Familiar								
Solver	7	15	16	13	10	9	9	5
Nonsolvers	1	3	2	5	8	9	9	13
Nonfamiliar								
Solver	17	17	15	11	10	9	9	5
Nonsolvers	1	1	3	7	8	9	9	13

AF = Affirmation, CJ = Conjunction, DJ = Disjunction, CD = Conditional

Reference Notes

1. Firestone, P., The effects of reinforcement contingencies and caffeine on hyperactive children. Unpublished doctoral dissertation. McGill University, Montreal, 1974.

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FIGURE CAPTION

1. Mean errors to soluation on four rule learning problems with familiar/ nonfamiliar shape attributes by normal and learning disabled children.